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LAT Balloon Flight Requirements Document

For the

GLAST LAT Project

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Contents

1 Introduction

1.1 Purpose

The purpose of this document is to establish and control the system level requirements for the development and flight of the GLAST Large Area Telescope (LAT) Balloon Flight Engineering Model (BFEM)

1.2 Scope

This document identifies and describes the functional and performance requirements for the BFEM. It is the source for technical requirements and is used by the LAT project office to manage the development and flight of the BFEM. The LAT project office is responsible for preparation, maintenance, and control of the this document. Any changes to its provisions and requirements must have prior approval of the LAT project office.

1.3 Definitions

Requirements shall be established independent of implementation considerations such as presently planned functional and organizational partitions. Requirements on individual components and processes of the BFEM will be derived from the requirements established in this document.

Analysis — A verification method where analytical tools and methods are used to verify compliance in the satisfaction of a requirement.

Compliance Measure — The parameter that must be verified to satisfy a requirement.

Demonstration — A verification method where performance of specific functions is used to verify compliance in the satisfaction of a requirement.

Inspection — A verification method where performance is directly measured or observed to verify compliance in the satisfaction of a requirement.

must — Used to describe constraints for which there is no design flexibility.

Rationale — Reference or description presenting the justification or interpretation supporting the establishment of a requirement.

Requirement — Characteristic identifying a level of performance necessary to meet objectives.

shall — Used to describe firm requirements that, while subject to trade analysis, are not part of the design trade space.

Test — A verification method where performance is measured against a standard as defined through a test procedure to verify compliance in the satisfaction of a requirement.

Verification Method — The action or activity to be used to demonstrate achievement of a requirement. Mothods are analysis, demonstration, inspection, and test.

will — Used to define operations and weaker requirements that are subject to trade study and optimization.

2 Applicable Documents

The following documents are cited in the text or provide specifications for the requirements:

GLAST00010	GLAST Science Requirements Document (February 8, 1999)
GLAST00110	Mission Assurance Requirements (MAR) for the Gamma-Ray Large Area Space Telescope (GLAST) Large Area Telescope (LAT) (June 9, 2000)
GLAT-00001	Guidelines for System Requirements Definition for the GLAST LAT Project (June 5, 2000)
CCSDS 102.0-B-3	Recommendation for Space Data Systems Standards. Packet Telemetry. (October 1989)
CCSDS 202.0-B-2	Recommendation for Space Data Systems Standards. Telecommand, Part 2: Data Routing Service. (October 1989)
CCSDS 201.0-B-2	Recommendation for Space Data Systems Standards. Packet Telecommand, Part 1: Channel Service
CCSDS 201.0-B-1	Recommendation for Space Data Systems Standards. Packet Telecommand, Part 2.1: Command Operation Procedures
	Report on the GLAST LAT Balloon Test Flight Objectives (July 12, 2000)
	Conventional Balloon Flight Support Application, Fiscal Year 2001, NSBF.

3 Balloon Flight Objectives

Both the NASA Announcement of Opportunity (AO 99-055-03) and the GLAST LAT proposal recognized the value of a balloon flight of prototype hardware as a way to confirm the ability of the GLAST LAT to operate in a space-like background environment. The hardware and software developed for the Beam Test Engineering Model (BTEM) will form the basis for the development of a Balloon Flight Engineering Model (BFEM).

The primary objectives of a balloon flight have been defined in the document Report on the GLAST LAT Balloon Test Flight Objectives, compiled by the Balloon Flight Objectives Working Group headed by T. Kamae. In summary: The purpose of the balloon flight is to expose the most flight-like prototype tower (BFEM) possible to a charged particle environment similar to the expected space environment and accomplish the following objectives:

1. Validate the basic LAT design at the single tower level.
2. Show ability to take data in the high isotropic background flux of energetic particles in the balloon environment.
3. Record an unbiased subset of particle incidences that can be used as a background event database.
4. Demonstrate an efficient data analysis chain that meets the requirement for the future GLAST Instrument Operation Center (IOC).

The first three objectives motivate more detailed objectives for each detector subsystem. The final objective motivates the IOC and Science Analysis Software detailed objectives.

3.1 ACD Objectives

1. Primary
   (a) Provide signals to the Data Acquisition System (DAQ) during BFEM instrument operation.
2. Secondary
   (a) Confirm laboratory measurements of the efficiency and hermeticity of the ACD
   (b) Measure the total charged particle rate.
3. Goals
   (a) Verify ACD efficiency/hermeticity. This goal requires at least 10^5 "clean" events in which a single track and a MIP signal in the calorimeter are recorded along with the ACD data. Approximately 3 hours of data are required to meet this goal.
   (b) Monitor total charged particle rates with the ACD. This goal requires that ACD VETO discriminator signals be scaled and recorded/transmitted.

3.2 Tracker Objectives

1. Test rejection of charged particle tracks.
2. Test performance of tracker trigger scheme.
3. Operate analog electronics in flux of heavily ionizing particles.
4. Test remote operation of silicon tracker in flux of heavily ionizing particles.

3.3 Calorimeter Objectives

1. Confirm the rejection factor for backward-moving photons and charged particle in trigger.
2. Study hit association (correlation) between the tracker and the calorimeter.
3. Study the calorimeter trigger. We may learn about the effect of the backward-moving flux by this trigger.
4. Test response of analog electronics to heavily ionizing particles.
5. Test possible latch ups by heavily ionizing particles in the photo diodes and readout electronics.
6. Temperature variation in the calorimeter.

3.4 Data Acquisition System Objectives

1. Obtain basic data needed for design of the flight trigger and DAQ.
2. Verify the L1T trigger.

3.5 GSE/IOC Objectives

1. Demonstrate Ground Support Equipment (GSE) capable of supporting data acquisition, archive, and display from the BFEM and of commanding the BFEM.
2. Acquire and display housekeeping data for verification of BFEM health and nominal operation.
3. Perform realtime acquisition and processing of a TBD percent of the event data to support data quality verification during the flight.
4. Archive of up to 100 GB (TBR) of realtime housekeeping and event data and prompt delivery to the SDPF.
5. Prototype IOC functions in support of flight IOC development.

3.6 Science Analysis Software Objectives

1. Acquire balloon flight data from GSE/IOC.
2. Develop reconstruction code to handle data from BFEM.
3. Develop automated server and relational database to support processing.
4. Select and develop event database.
5. Verify data processing preflight in Mock Data Challenge.
6. Investigate capability for prompt monitoring and development of high level diagnostics for GSE/IOC.

4 Balloon Flight Constraints

The objectives for the balloon flight identified in section 3 must be accomplished within existing programmatic constraints:

1. The balloon flight must be accomplished within the total budget of $1,050k allocated in the GLAST LAT proposal.
2. Findings from the balloon flight shall be available in a timely fashion to support flight instrument development.
3. The balloon flight must minimize interference with flight instrument development.
4. No single person involved in GLAST flight instrument development shall be dedicated to the balloon flight at 100 percent time.
5. The cost and schedule goals will be achieved by re-using, wherever possible, instrumentation and other resources from the beam test engineering model (BTEM) and existing balloon flight instruments.

5 Functional and Performance Requirements

5.1 Management Requirements

1. Balloon flight planning, BFEM development and flight shall be coordinated by a small and experienced management team drawn from areas not critical to flight instrument development.

2. BFEM development shall be performed within the existing flight instrument organization, subject to the oversight and coordination of the management team.

3. No single individual will be more than 50% dedicated to the balloon flight activity.

5.2 Flight Requirements

1. The balloon flight will be performed at an NSBF facility in the continental US.

2. The balloon flight will be completed by July 31, 2001 with a goal of completion by June 15, 2001.

3. The balloon flight shall be a high altitude flight with a minimum altitude of 115,000 feet (35 km) and a goal of 125,000 feet (38 km).

4. The balloon flight altitude at float shall be stable to $\pm$5,000 feet (1.5 km) with a goal of $\pm$2,000 feet (0.6 km).

5. The balloon flight duration shall be a minimum of 5 hours at float with a goal of 8 hours at float.

5.3 Data Acquisition Requirements

1. A minimum of 500,000 events (TBR) shall be recorded from the BFEM during the balloon flight.

2. The BFEM readout deadtime shall be no more than 100 μsec.

3. The BFEM shall acquire more than 10% of the possible events on average without introducing systematic bias into the data acquisition.

4. The BFEM shall be capable of sustaining peak readout rates for at least 200 msec every second.

5.4 BFEM Performance Requirements

5.4.1 ACD

1. ACD signals (pulse heights or disciminators) for minimum ionizing particles (MIP) shall be delivered to the DAQ during data acquisition such that the data can be correlated with corresponding tracker and calorimeter data.

2. The ACD shall operate successfully at float for at least 1 hour.

5.4.2 Tracker

1. The tracker shall operate successfully at float for at least 1 hour.
2. The tracker temperature shall be maintained between 0 degC (TBR) and 25 degC during operation.
3. The tracker temperature shall be maintained between -10 degC (TBR) and 30 degC during non-operation.

5.4.3 Calorimeter

1. The calorimeter shall operate successfully at float for at least 1 hour.
2. The calorimeter temperature shall be maintained between 0 degC (TBR) and 25 degC during operation.
3. The calorimeter temperature shall be maintained between -10 degC (TBR) and 30 degC during non-operation.

5.4.4 Data Acquisition System

1. The BFEM DAQ shall operate successfully at float for at least 2 hours.
2. The BFEM DAQ shall support L1T and data acquisition at the 1kHz (TBR) environmental rate.
3. The event dead-time shall be no more than 100 μsec.
4. The BFEM DAQ shall include mass storage sufficient to archive 10 hours of event data at the environmental L1T rate.
5. The BFEM DAQ shall provide balloon-specific trigger modes including a minimum bias trigger and an artificial target trigger (TBR).
6. The BFEM DAQ shall perform data acquisition for the artificial active targets.
7. The BFEM DAQ shall accept commands from the NSBF transceiver.
8. The BFEM DAQ shall perform data acquisition for housekeeping sensors.
9. The BFEM DAQ shall perform power switching and control for +28VDC from the NSBF provided batteries.

5.5 On-board Software Requirements

1. The on-board software shall make provision to save as much raw data as possible with possible sampling with time-stamps.
2. The on-board software shall record housekeeping data.
3. The on-board software shall provide for 10 hour total record time = 36 GB if one event occupies 1kB.
4. The on-board software shall handle commands for the BFEM.
5. The on-board software shall accommodate a limited set of options of data taking modes including a minimum bias mode and an artificial target trigger mode.

5.6 Science Analysis Software Requirements

1. The Science Analysis Software shall archive all balloon flight data.
2. The Science Analysis Software shall include the ability to model BFEM performance and simulate BFEM data.
3. The Science Analysis Software shall be able to reconstruct events from the BFEM data.
4. The Science Analysis Software shall be able to convert event data into flux values, energy spectra, and angular distributions for both particles and gamma-rays.
5. A preliminary science analysis of the balloon flight data shall be available within 6 weeks of receipt of data from the balloon flight.

6 Interface Requirements

6.1 NSBF

1. The BFEM shall send telemetry and acquire commands from the NSBF transmitter via TBD interface.
2. The BFEM shall acquire power from the NSBF batteries via TBD.

6.2 Gondola Mechanical Interfaces

1. TBD

6.3 Gondola Electrical Interfaces

1. TBD

6.4 Ground System

1. During flight, the BF GSE shall receive telemetry from the NSBF facility via TBD electrical interface.
2. During flight, the BFEM Operator shall send commands to the NSBF Command Management System (CMS) facility via RS232 serial interface.
3. The BF GSE shall recieve TBD watts of 110 V power from the NSBF facility via TBD.
4. The BF GSE shall have a connection to the internet via TBD interface.
5. During ground test, the BF GSE shall have access to test ports on the BFEM for command and data acquisition.
6. During ground test, the BFEM and BF GSE shall be maintained in a controlled access work area of at least 1200 sq. ft with environmental control for temperature and humidity..
7. During ground storage, the BFEM and BF GSE shall be maintained in a controlled environment for temperature, humidity, and access.